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Semantic Technologies: a Transformative Approach in Public Libraries

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Abstract

The advancement of the digital era technology has changed how people access and use information. These changes were necessitated by the introduction of the internet and the World Wide Web. Currently, most library users are interested in instant access to information and not the procedure, interested in prompt feedback and not procrastination. Semantic technologies seem to be a solution to the prevailing problem; however, the uptake has not been impressive among libraries. Semantic technologies are tools that can assist library users in prompt searching and retrieval of information with minimum bureaucratic procedures, tools that ensure that every library search query is meaning defined, this is unlike the conventional library systems.

This paper discusses the importance of semantic technologies in public libraries and how these technologies can be implemented for easy-to-use tools and applications for public library users. The research paper explores the benefits of semantic technologies usage as a key and effective factor of searching and processing data in the everyday life of library users. Moreover, the article sheds light also on the challenges that public libraries may face when trying to introduce semantic technologies to their users, as well as the social and cultural constraints that make their implementation elusive.

Keywords: Public Libraries, Semantic Technologies, Semantic Web, Digital Skills

1. Introduction

The modern present age is characterized with the human-machine contact more than human-human contacts. This is mainly due to different changes within the social and cultural interactions within societies, that are sequels for the technological advancements. Humans are more connected to their phones, laptops, tablets, etc. than to each other, as societies tend to bow more and more toward individualistic and independent actions, favouring quick, efficient, and time-saving apparatus that can provide the assistance with less interference of another third party human action. It is no question that these human-behaviours have negative impacts on the social interactions inside the societies, however, it cannot be denied that there are many positive results on self-confidence and the way that human individual learning grows and flourish. Rogers (2007) in earlier studies observed that with the introduction of the web more people are slowly adopting the web technology and shunning the traditional ways of accessing information and knowledge. According to Chang et al. (2013), there is a need for new ways on how to encourage learning from web knowledge, and which semantic technologies can help doing it. Chang et al. (2013) citing Liu et al. (2010) assert that semantic technologies can assist their users in exploring new knowledge in a structural way that serves the people with limited knowledge about the web. Wohlgenannt (2011) asserts that semantic web can help "smarter applications perform to their potential" (p.24). Semantic technologies are concerned with helping Artificial Intelligence (AI) in creating a meaning of the human environment the way that humans do.

The use of semantic technologies (ST) in libraries can serve the users in their queries and research as ST are able to store, manage and retrieve information according to the rational connections. According to a definition given by Vaughan (2021), the purpose of using semantic technologies is to enable machines to handle and manage information on the behalf of humans in a meaningful way. Semantic technologies enable understanding and giving

meaning to the human surrounding based on available data. Semantic technologies link different formats and sources of data to create significance from it. Wohlgenannt (2011) alludes that there are two interpretations for the semantic web technologies. The first interpretation"aims towards the integration of structured and semi-structured data sources over the Web in order to federate and re-use those data sets"..."The second interpretation focuses on the enhancement of the current Web content with additional semantic metadata - where techniques such as concept extraction, named entity recognition, automatic classification extract the metadata automatically" (p.24).

2. Methodology

This paper adopted the literature review approach, Snyder (2019) citing Baumeister & Leary (1997); Tranfield, Denyer, & Smart, (2003) notes that "literature review can broadly be described as a more or less systematic way of collecting and synthesizing previous research". The author argues that literature review method is a perfect way of combining various empirical researches and synthesising their findings to establish new knowledge and gaps. From the interdisciplinary and multidisciplinary nature of this study, it was found appropriate to use a literature review methods due to the following reasons; The study was focused on public libraries in general as such obtaining empirical data was not found to be appropriate, the study is a multidisciplinary oriented that involves the integration of information technological components into the study while concentrating on the current trends in public libraries and users information needs. Therefore, literature review was found adequate so as to limit the study scope and give it adequate attention to its main objective.

3. Why Public Libraries

Public libraries serve a diverse group of users who access them voluntarily for personal, family and community development (Scott, 2011), this is contrary to the school and academic libraries that have a defined target user. They carry out exceptional and crucial roles in their respective communities, which include the cultivation of reading habits among the young adults, enhancement of literacy skills among adults and early childhood, supporting government programs, participation in national, regional and local economic development, among other functions. Therefore, for effective service delivery, public libraries need to be well prepared and ready to serve the cosmopolitan and ever-changing user information needs. Harding (2008) argues that public libraries have been considered as institutions that have failed to address the issue of information literacy among their users, according to the authors, the availability of information literacy programs in public libraries would enhance wide access and maximum utilization of public library information resources by its users. Nielsen & Borlund (2011) allude that the challenges that have always faced public libraries in regard to information literacy are that they are focused on users' information needs beyond the formal teaching and learning environment. Therefore, the mandate of public libraries is not to teach, but to provide access to a wide range of information resources. Matteson & Gersch (2020) point out that the hindrance faced in organizing information literacy in public libraries is because, public libraries are not educational institutions, hence, their systems are not well structured, most library patrons lack the motivation to be enlightened about information literacy and finally the issue of time of organizing such pieces of training among the library patrons. Moreover, public libraries limit their usage on specific applications and tools, instead of using semantic technologies and semantic web, which can result in constraining the services they provide to their users. Wohlgenannt (2011) states that "most of the existing applications only consume their own data, rather than the Semantic Web as a large scale information source" (p.26). Therefore, the introduction of semantic technology in public libraries will bridge the gap that has been associated with the lack of information literacy in public libraries.

Public libraries are considered to be serving a bigger population after school libraries, IFLA (2022) reveal that globally, there are approximately 2.2 million school libraries, 408,823 public libraries, 84,392 Academic libraries, 24,241 community libraries and 38, 937 other types of libraries which constitute 79.7%, 14.9%, 3.1%, 1.4%, 0.9% and 0.1% respectively. From these records, it can be construed that if a country wants to change the reading trend of a population, public libraries shouldn't be ignored. However, Rogers (2007) notes that the changing perception of libraries among the current generation is best observed by the academic libraries. This study focuses on public libraries since they are considered to be servicing a larger population of users with varied needs. Furthermore, with the proliferation of advanced technology, public libraries need to position themselves ahead of technology lest their roles and functions are considered redundant and services ignored. With the introduction of the internet and the widespread use of information resources in all forms, public libraries deserve to position themselves strategically so that their role will still be appreciated by the general public. Therefore, for effective usage and maximum utilization of public libraries it is prudent to introduce semantic technologies as a transformative approach since it has been noted in numerous researches (Matteson & Gersch, 2020; Demasson et al., 2019; Lyakurwa & Luambano, 2019; Kingori et al., 2016) concerning the hindrance that public libraries have faced in conducting information literacy trainings. Chang et al. (2013) citing (Chyan et al., 2007; Koper, 2004; Ma¨kela¨, 2005; Tiropanis et al., 2009) assert that "semantic technology is regarded as a potentially effective approach to helping users learn on the web" (p.379).

According to Alias et al. (2010), citing Warren et al. (2005), libraries face challenges regarding the interoperability of a semantic document retrieval when searching for information.

4. Semantic Technologies and Semantic Web

According to Yadagiri and Ramesh (2013) Semantics came from a Greek word "sema" which means "sign" its adjective is semantikos meaning "Significant". Cambridge Semantics website (2022) reveals that semantic technologies are useful tools that have their roots in Artificial Intelligence (AI), and which are designed to extract "meanings from information". Taking the example of AI technologies, they are created and designed to give answers based on "reasoning models", and which rely on machine-learning algorithms "that can improve the system's decision-making capabilities over time" (Cambridge Semantics website, 2022). Another two examples that are mainly used in libraries are the semantic search, which is based on concepts searching for finding information instead of best-matched, using keywords and phrases.

On the other hand, semantic web technologies are considered as rules set by the World Wide Web Consortium (W3C) that allow the description and linkage of information and data (Cambridge Semantics website, 2022). Examples of the semantic web standard are the flexible data model (RDF), query language (SPARQL), rules language (RIF), etc. O'Hara & Hall, (2018) citing Berners-Lee (1998) alludes that the Semantic Web assist in the conversion of reasoning from documents to data with the aim of facilitating the reuse of data, it assist in reducing the human labour cost of information processing and conversion and also assist in dissemination and access of large quantity of information that is stored in Relational Databases (RDBs) by converting it to machine-processable. Yadagiri and Ramesh (2013) citing Berners-Lee (1999) defines Semantic Web as "a web of data that can be processed directly and indirectly by machines". Bygstad et al. (2009) assert that semantic web and semantic technology are involved in the access of information through the use of ontologies. Georgieva-Trifonova et al. (2019) note that semantic web ensures that the information and knowledge in the web is able to be processed by computers while semantic technology supports semantic web functions. As such, it can be concluded that semantic web ensures the integration, operability, interoperability between various systems. Yadagiri and Ramesh (2013, p. 81) allude that that "Semantic Web provides a common framework that allows data

to be shared and reused across applications, enterprise, and community boundaries". The authors note that the term semantics, metadata and ontologies are synonymously used to refer to semantic web. Additionally to this, Berners-Lee et al. (2001), as cited in Yadagiri and Ramesh (2013), state that the Semantic Web enables a better cooperation and collaboration between men and machines as it represents an adjunct to the prevailing web as it provides information in meaningful structures and definitions (p.82).

5. Application of Semantic Technology and semantic web in Public libraries

With the advancement in technology and massive access to information resources in a variety of forms, it is of great importance that public libraries adopt the use of semantic technology. Semantic technology in public libraries will involve the introduction, digitization of information resources that will enable the conversion of any search query into prompt access of the intended information. Application of semantic technology in the public libraries can be applied through the following ways;

- **Federated searching:** The introduction of federated search engines came as a result of the availability of very many databases that offer access to numerous information resources on the web. As such, it became difficult for library users to access all the databases. There are various synonyms for federated searching which include meta-searching, cross-database searching, multi-database searching, multi-threaded searching, one-stop searching, poly-searching, broadcast searching, and searching through a portal or gateway. Federated search engines relieve a library user of the problem of searching numerous databases that are available in the library. Gray & Olfman (2018. P. 704) allude that "federated search engines that combine databases, the online catalog, Web sites, and Open URL link resolvers" according to the authors, these links provide access to a variety of information from full text, abstracts, citations etc. Rai et al. (2008) assert that federated search engines makes it easy for library users to search information from multiple databases with a single search query, hence, reduces searching time and increases access to multiple resources. Randall (2006, P. 182) states that "in the world of federated searching, however, sorting by relevance is a tall order due to the fact that different database vendors determine relevance in different ways and provide different amounts of metadata"

- **Universal library services (Library portal):** Most public libraries have been on the verge of collecting and acquiring a huge and wide range of physical information resources over the years. However, with the digitization and easy access of a wide range of information materials on the web, physical information is no longer considered a preferred preference for many. This can be alluded to by the fact that most library users are not interested in the process of accessing information, but rather interested with prompt access to information. Bouaamri et al. (2022) argue that most library users are slowly retracting from accessing physical information resources to electronic contents. Therefore, public libraries should consider generating meaning into the resources on the library portal/catalogue so that library users can be able to access the content from it. Some of the ways that the library can incorporate these are as follows;

    - **Linking physical information resources to available electronic format:** Public libraries can seek ways of establishing the availability of the available books and information resources in their respective libraries in electronic format and purchase them. With the current digitization, most book publishers provide access to books in both electronic format and print format, as such, public libraries can link the physical books with the electronic books in the library portal/catalogue so that library users can be able to access both formats and decide their preferred format. Through such linking, it will be easy for

library users to access the contents of various physical books in the public library. Yadagiri and Ramesh (2013) allude that the library portal should be able to search across various heterogeneous information resources in the library

- **Extraction of book synopsis/ table of content:** Public libraries can also decide to extract the table of content from the physical information resources and provide them in their library portal/catalogue. However, this strategy is not quite efficient in extraction of meaning to the readers but it will be able to access library users to establish the contents of most of the information resources in the library. This strategy will also depend on the compatibility of the library management software being used by the respective public libraries

- **Digitization of library books:** Public libraries can also decide to digitize their library collection. Digitization will involve the conversion of the physical books into electronic format. However, this move should be done with caution so as to avoid the infringement of the copyrighted books. Franklin-Brown, (2017) observes that the digitization of books by Ghent University in Belgium has been able to make information accessible easily and widely, hence creating meaning to any search query. Ghent University went into partnership with google in 2007 and started the digitization of books that are out-of-copyright (Mantels, 2019). As such most of the rare physical books have been able to be made accessible by library users. This is one of the examples through which public libraries can consider engaging themselves with.

The application of semantic technology is not an easy task for any library, this is due to the fact that it involves adequate qualified staff, proper infrastructure and adequate financial support. However, in the long term the benefits accrued to the efforts are worth the investments.

6. Importance of Semantic Technologies and Semantic Web in public libraries

The importance of semantic technology/web is immense, the semantic technology has been able to bring meaning to words and equally assisted in distinguishing synonyms, hence simplifying users information searching and seeking behaviour. These functionalities of semantic web have been made possible by the introduction of information exchange application integration such as Web Services Description Language (WSDL), Extensible Markup Language (XML), Resource Description Framework (RDF), and Simple Object Access Protocol (SOAP) among others. According to Zeng & Chan (2018), Semantic Web standards such as Resource Description Framework (RDF), Simple Knowledge Organization System (SKOS), and Web Ontology Language (OWL) facilitate metadata discovery, re-use, harmonization, and synergy across diverse disciplines and communities practice, thereby promoting wider adoption, standardization, and overall interoperability. However, for this study we focus more on significance emanating from the end users perspective and not on the complexity of the semantic web in terms of compatibility and integration, internal uniformity and consistency, interoperability, information integration etc. Therefore, the importance of incorporation of semantic technologies and semantic web in the public libraries are as follows.

- **Signs and Meaning:** The introduction of library automation services to public libraries using Library Management Systems (LMS) came about with a lot of excitement, however this excitement was short lived. LMS is dependent on Library classification which does not extract the subject from the document, but rather builds the subject and expresses it in the indexing language, this unlike Semantic Technologies. Andersen (2015) supports this by stating that the library catalogue

whether automated or manual cannot assist library users to get access to the requested full text information but rather they offer links or directions to where the source of information is located or stored within the library, they offer access to information but do not provide meaning or full text. Joint (2009) argues that a library Online Public Access Catalogue OPAC is never a one stop search for libraries as it is not able to provide instance required information to library users. The use of semantic web gives prompt feedback to requested information.

- **Cost-effective for public libraries**: Public libraries being one of the largest information institutions in any country, they are exposed to a lot of expenditures, for instance capitation funds, wages and salaries, recurrent costs, maintenance costs etc, however with application of semantic technologies and semantic web, access to public libraries can easily be on remote access. Therefore application of the semantic technologies can be cost-effective for institutions such as libraries to organize and manage their internal data. Yadagiri and Ramesh (2013) allude that the aim of Semantic web is to enable people to have a full access and exploration of the web in a cost effective way.
- **Wide access of users:** Semantic technology is only available on the digital form therefore it implies that if public libraries implement semantic technology in their respective libraries information resources will be accessed virtually or in the digital format. Unlike the physical book/information material that give provision for one book per user, in the digital format, one book can be accessed by several individuals at the same time. As such library users are able to be given instance feedback of their information queries.
- **Enhancing the usage of Digital Libraries** digital libraries are becoming more and more important in the everyday life of every person. Digital libraries rely on the metadata descriptions (Alias et al., 2010) that allow the retrieval and storage of information and data. However, according to Alias et al. (2010), these metadata are not sufficient and do not permit the semantic search and retrieval of data, the reason why digital libraries should hinge on ontologies as a semantic solution to cover this gap (Alias et al., 2010). The authors add that using ontologies offer the combination of semantic metadata as well as concepts in a formal semantic approach. The purpose of semantic technologies used in digital libraries is to enhance the search on a deeper level of categorization which allows the semantic identification of the content of any document.
- **Consolidation of information resources**: The current diversity nature of information resources is creating a lot of difficulty for library users to easily explore the range of information resources available. Most library has access to print books and other information resources, electronic journals, electronic books, repositories, Online Public Access Catalogues, web portal etc Access to this noble resources is likely to be tedious and frustrating if libraries have not linked all this resources using semantic web technologies like federated search engines, link resolvers, library portal etc. Yadagiri and Ramesh (2013) alludes that semantic web is advantageous as it is used to link information together, the author alludes that librarians as information professional should adopt semantic web technologies so as to consolidate information resources in the libraries.

7. Challenges

Using semantic technologies in libraries can be very challenging and complicated, especially at the initial stages. The challenges can be divided into two sections, the library management challenges and the semantic technology challenges. These are some of the obstacles that can face the implementation of semantic technologies in public libraries in regards to public library management are as follows ;

- **Constraints of adequate funding:** The implementation of semantic technologies and professionals to handle them is an investment that not all libraries can afford. The implementation of semantic technologies at its initial stage is usually expensive to adopt as it requires both infrastructure and a competent workforce who are able to handle the technologies introduced into the public libraries. Salman et al. (2018) note that most public libraries are faced with similar problems of lack of adequate finance, lack of still with IT skills and equally demotivated library staff. Warraich et al. (2018) argue that if public libraries are expected to transform a community, then the government should ensure that adequate funds are allocated to public libraries as it has been noted that financial constraints are one of the main challenges facing the advancement of public libraries. Without adequate funding, employment of qualified skillful staff, acquisition of appropriate infrastructure, subscription to books and acquisition becomes elusive. These sentiments are also supported by (Islam et al., 2022).
- **Resistance to change:** Esteves & Alves (2013) note that with the introduction of new technology in libraries there is always the possibility of resistance among staff, however library leaders should devise appropriate strategies of dealing with such challenges. Resitance to change has also been mentioned by Musangi et al. (2019) who argues that libraries are never keen to implement new services due to the fear of resistance among staff. In essence, most new projects are always a victim to resistance to change due either worries that there might be lose of job or laxity of staff to learn new skills, as knowledge is constantly updated, and machines will need human understanding to guide them at the beginning to be able to run and manage data for the long term. Campbell & Fast (2004) in earlier studies notes that the introduction of semantic web in libraries makes librarians work in technical services redundant as most information resources in the libraries are acquired with full descriptions.
- **Human disagreement** which is one of the most important challenges when implementing semantic technologies in libraries can be human disagreements, that is the knowledge shared and information search and found are not hundred percent satisfying to the users. Wohlgenannt (2011), citing Shirky (2003), states that "the Semantic Web with its "neat ontologies and syllogistic logic" is not that effective in the real world where a shared world view is hard to create" (p. 28).
- **Verification and update of information and knowledge categorization** It is important for humans to have updated information. Information, Knowledge and science are in constant updates, hence, semantic technologies need a constant check and update of the knowledge stored and saved. Bouaamri and Hajdu (2021) allude that humans organize knowledge into categories "that are based either on scientific discoveries or social, cultural, and political settings" (p. 164). According to Bouaamri and Hajdu (2021), "how categories are perceived and placed are necessary to be discussed in order to comprehend how knowledge is constructed and put together" (p.164). As such, as categories and knowledge structures are in constant change and modification, it is consequential to revise the semantic technologies categorizations frequently.

8. Semantic technology challenges

Change is inevitable, the change and advancement in technology is continuous, advancement of technology brings two perspectives, that is either an organization will be expected to upgrade their existence technology or required to completely shift into new technology. Some of the challenges that occur with the adoption of semantic technology in public libraries are as follows;

- **Compatibility and integrated information search:** Zeng, M & Chan, M. (2004) compatibility is a system attribute that allows goods to be interchanged without the need for specific conversion apparatus, despite differences in notation, structure, and physical carriers. The issue of compatibility among different semantic web systems is more envisaged during the current internet and online era. Compatibility is thus focused on enabling cross-database searching inside a certain service or facility, such as an online database service or an OPAC. AS search all the semantic technology adopted should be able to integrate with each other so as to ensure comprehensive search. For instance, there are many library management systems in the market, however not all are able to handle the electronic journals and books.

- **Lack of internal uniformity and consistency:** Because integrity constraints might be applied, it's critical to ensure internal consistency in the expression of knowledge, this is usually made possible by explicit semantics. Yu & Chen (2001) note that the use of XML, for example, can assist in the conversion of non-structured data into semi-structured data, thus facilitating information sharing across different information systems.

- **Challenges associated with interoperability:** Because equivalent concepts in various Knowledge Organization Systems have the same unique identifier, regardless of the exact lexicalizations used to represent those concepts, explicit semantics enables interoperability. Knowledge sharing and reuse are facilitated by semantic interoperability. ALA (2000) defines interoperability as the capacity of two or more systems or components to communicate information and utilize it without requiring additional effort on the part of either system. Zeng & Chan (2004) attests that proper interoperability will result in the integration, mapping, and creation of Knowledge Organization Systems for information sharing in a networked conducive environment.

- **Relevancy in Ranking challenges:** Different semantic tools have different ranking systems of relevancy, therefore library users should be conversant with the ranking systems of query listings. The order in which the results of a search are presented by discovery services is crucial. Given the enormous amount of data in their indexes, it's vital that the items that best match the query appear near the top of the results list. If they do not have a full understanding of the discipline, users who do not have the patience to wade through multiple pages of results may choose resources to use for their research.

9. Recommendations

Though the adoption of semantic technologies in public libraries is a noble idea, targeted to enable users with minimal user education training on libraries to have access to library resources, it is still important for public libraries to consider establishing appropriate information literacy training to users. Public libraries have mostly failed to offer information literacy to users which usually leads to low usage and exploration of the wide available information resources in the library (Karimi, 2017). With low usage of information resources of public libraries, it becomes very difficult for public libraries to justify additional funds, additional new staff and also the need to update the existing infrastructure since it will seem to be a waste of taxpayers' money for a government. The application of semantic technology in public library is quite involving and public libraries should consider establishing partnership or collaboration if the approach is to be elusive, Mantels (2019) note that collaboration of Ghent University library book tower and Google book has enabled the university digitize a lot of rare, ancient and special collection that can now be easily

accessible through the university library portal. Public libraries also should seek the support of technologies' companies, producers and providers as a way to promote their products, but also direct their industry to the importance of innovative and new technologies for libraries.

10. Conclusion

Public libraries offer an open environment to the general public to explore and discover new technologies. As such, they should consider venturing into having a priority and a variety of information resources in various forms, means and accessibility. For instance, they can provide machines that can recognize the users' inquiries just by speaking (voice/audio), analyzing and locating the items and documents for them, especially, for those who have little knowledge about how to search for information, or those who lack information literacy as well as user education skills, or even serve those with disadvantages (blind, deaf, etc.). Incorporation of semantic technologies in public libraries is a big step forward and with many challenges and obstacles. However, it is a long-term investment that can provide a great assistance in terms of information literacy, how to search for information, locate it, analyze, and use it. Moreover, public libraries can make use of semantic technologies to inform their users and keep them updated about upcoming events, recommendations of books and documents. It can also assist them in the catalogue search, and connect and orient them to other collections from other libraries (in their network or outside of the network) in case the library doesn't hold what they needed. Semantic technologies if adopted and adapted to the library settings can help the users in finding and locating the right information with the minimum efforts. It can also make the work of library professionals easy as semantic technologies allow the storage and the caption of outside information that are given by the users.

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